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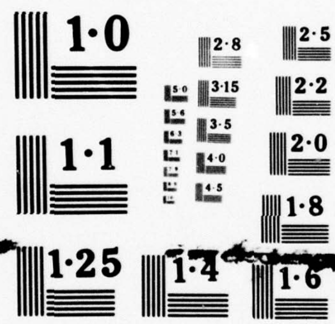

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NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 7-78

6 COMPARISON TESTS OF THE USN MK 1 MOD 0 MASK IN STANDARD CONFIGURATION AND THE USN MK 1 MOD 0 MASK WITH SCUBAPRO PILOT SECOND STAGE AT VARYING SUPPLY PRESSURES.

BY

10 JAMES R. / MIDDLETON

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12 36p.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NEDU REPORT 7-78	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMPARISON TESTS OF THE USN MK 1 MOD 0 MASK IN STANDARD CONFIGURATION AND THE USN MK 1 MOD 0 MASK WITH SCUBAPRO PILOT SECOND STAGE AT VARYING SUPPLY PRESSURES		5. TYPE OF REPORT & PERIOD COVERED Test Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) JAMES R. MIDDLETON		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Navy Experimental Diving Unit Panama City, FL 32407		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE March 1978 13. NUMBER OF PAGES 33
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Open circuit	Exhalation	Tidal volume
Breathing resistance	Sideblock	
Work of breathing	Umbilical	
Over bottom pressure	Respiratory minute volume (RMV)	
Inhalation	Breaths per minute (BPM)	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The USN MK 1 Mod 0 mask in standard configuration was tested unmanned at varying air supply pressures to determine the minimum acceptable over bottom supply pressure. These tests were run in an effort to duplicate and verify results achieved in an NEDU manned test described in reference 3. Various breathing rates and tidal volumes were tested at varying depths until breathing resistances similar to those achieved by working divers in reference 3 were attained. This

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combination of breathing rate and tidal volume was then used for the duration of the tests.

This test is significant in that this is the first attempt to exactly duplicate manned test results in an unmanned test situation. That results were almost identical lends credibility to unmanned test simulations and their place in equipment evaluations.

Results verified those found in reference 3. A minimum of over bottom air supply pressure of 135 psig must be maintained at the diving console to prevent excessive inhalation resistance in heavy work conditions.

In addition the MK 1 Mod 0 mask was then modified to accept a Scubapro Pilot second stage and tested under the same conditions as the standard configuration. No significant improvement in mask performance was observed when using the pilot second stage in place of the MK 1 Mod 0 regulator. A minimum of 135 psig O/B was still required to prevent excessive breathing resistance under heavy work conditions. Further investigation into adapting the Scubapro pilot to the MK 1 Mod 0 mask is not recommended.

Acknowledgements

The author would like to express his sincere appreciation to Mr. G.W. Noble and the personnel of the Naval Coastal Systems Center Hydrospace Laboratory.

In addition to the generous use of their sophisticated test facility, the high level of technical expertise, and tireless effort were instrumental to the successful and timely completion of these tests.

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Glossary

Abbreviation	Definition
BPM	breaths per minute
cm H_2O	centimeters of water pressure (differential)
fsw	feet of seawater
HeO_2	helium-oxygen breathing gas
I.D.	inside diameter
kg.m/l	breathing work in kilogram meters per liter ventilation
LPM	liters per minute (flow rate)
mil spec	military specification MIL-R-24169A
NEDU	Navy Experimental Diving Unit
O/B	over bottom pressure
ΔP	pressure differential
psig	pounds per square inch gauge
RMV	respiratory minute volume in liters per minute
USN	United States Navy

Abstract

The USN MK 1 Mod 0 mask in standard configuration was tested unmanned at varying air supply pressures to determine the minimum acceptable over bottom supply pressure. These tests were run in an effort to duplicate and verify results achieved in an NEDU manned test described in reference 3. Various breathing rates and tidal volumes were tested at varying depths until breathing resistances similar to those achieved by working divers in reference 3 were attained. This combination of breathing rate and tidal volume was then used for the duration of the tests.

This test is significant in that this is the first attempt to exactly duplicate manned test results in an unmanned test situation. That results were almost identical lends credibility to unmanned test simulations and their place in equipment evaluations.

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In addition the MK 1 Mod 0 mask was then modified to accept a Scubapro Pilot second stage and tested under the same conditions as the standard configuration. No significant improvement in mask performance was observed when using the pilot second stage in place of the MK 1 Mod 0 regulator. A minimum of 135 psig O/B was still required to prevent excessive breathing resistance under heavy work conditions. Further investigation into adapting the Scubapro pilot to the MK 1 Mod 0 mask is not recommended.

I. INTRODUCTION

In June 1977, NEDU initiated a series of unmanned tests of the USN MK 1 Mod 0 mask to determine minimum acceptable overbottom supply pressures at normal operating depths. These tests were conducted to verify a previous manned study described in reference 3. In addition, the MK 1 Mod 0 mask was modified to accept a Scubapro Pilot second stage, manufactured by Undersea Industries, 3105 East Harcourt, Compton, California 90221. Identical unmanned tests were conducted on the modified MK 1 Mod 0 mask to determine if any advantage (i.e. lower overbottom supply pressures) could be gained through the use of a balanced, pilot assisted second stage.

All tests were conducted at a single RMV, 75 LPM, which was found to most nearly duplicate breathing resistance and working conditions developed during the manned diving in reference 3. The mask was tested in conjunction with 400 feet of 3/8" I.D. standard diving hose, as were the manned dives.

Pressure drop across the mask sideblock was monitored in both mask configurations as was breathing work required to operate the regulators at all test depths. These measurements provided supplementary guides to evaluation.

Test results showed almost identical mask performance in both configurations (i.e. standard and modified with the Scubapro Pilot second stage) regardless of overbottom supply pressure. Minimum required overbottom pressure verified the results of reference 3 by showing that 135 psig O/B is required to prevent excessive breathing resistance at heavy diver work rates regardless of depth.

II. TEST PROCEDURE

A. Test Plan. NEDU test equipment was set up as shown in Figure 1. The test plan is given in Appendix A. The breathing machine was used to simulate inhalation and exhalation at a diver work rate of 75 RMV. Both mask configurations were tested at various depths and overbottom supply pressures to evaluate performance over a wide range of operating conditions. The following parameters were controlled, measured, computed and plotted. The test equipment shown in Figure 1 is listed in Appendix B. NOTE: Only the second stage demand regulators and sideblock were used since the mask frame would have no affect on results and its absence facilitated test set up procedures.

B. Controlled Parameters. The following parameters were controlled during the tests:

(1) Incremental depth stops: 30, 60, 100, 130, and 190 FSW

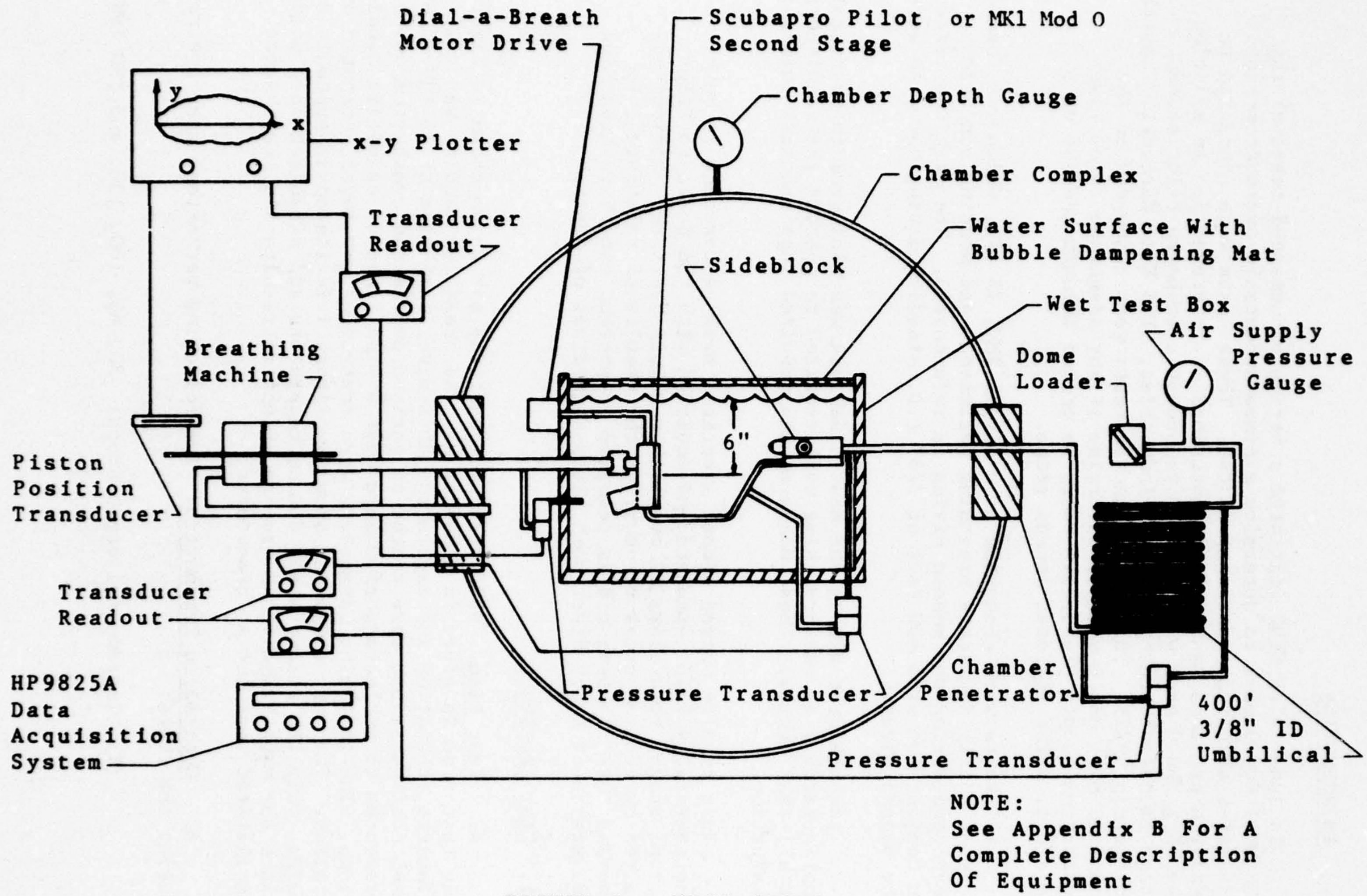


FIGURE 1. TEST SETUP

(2) Overbottom supply pressures to manifold: 130, 115, 95, 75, and 60 psig

(3) "Dial-A-Breath" position: The valve was opened by a remotely controlled motor drive until 0.15 cmH_2O free flow pressure was achieved and then closed 1.5 turns at each overbottom supply pressure and depth.

(4) Breathing Rate / Tidal Volume / RMV

Breathing Rate	Tidal Volume	RMV
30 BPM	2.5 Liters	75 LPM

NOTE: At 190 FSW the RMV was dropped to 62.5 LPM (25 BPM and 2.5 liter tidal volume) to more closely simulate results achieved in reference 3.

(5) Breathing waveform: sinusoid

(6) Exhalation/Inhalation rime ratio: 1.00/1.00

(7) Supply gas: air

(8) Gas supply mode: umbilical only

C. Measured Parameters. The following parameters were measured during the tests:

(1) Inhalation maximum ΔP

(2) Exhalation maximum ΔP

(3) ΔP vs. tidal volume plots

(4) Dynamic pressure drop across sideblock

D. Computed Parameters. Respiratory work was computed from the ΔP vs. tidal volume plots.

E. Data Plotted. The following data are plotted in this report:

(1) Inhalation maximum ΔP vs. depth at each O/B supply pressure tested

(2) Exhalation maximum ΔP vs. depth at each O/B supply pressure tested

(3) Respiratory work vs. depth at each O/B supply pressure tested

(4) Dynamic sideblock pressure drop vs. depth at each O/B supply pressure tested

III. RESULTS AND DISCUSSION

A. Description. The USN MK 1 Mod 0 mask is an open circuit full face mask with oral-nasal cavity which is designed for surface supplied air diving. The mask has the capability of operating in either the demand or free flow mode. The demand mode incorporates a "Dial-A-Breath" valve which allows a diver to maintain low breathing resistance regardless of air supply pressure. The "Dial-A-Breath" valve can also be used to create a free flow mode through the demand regulator. The divers exhaled gas is vented through the exhaust valve in the demand regulator assembly or through a supplemental exhaust valve located beneath the demand regulator housing.

The standard MK 1 Mod 0 second stage is a U.S. Divers Company Conshelf XII, conventional downstream type demand regulator, modified with the "Dial-A-Breath" adjustment to enable it to operate at varying overbottom supply pressures.

For the second phase of tests, the standard second stage was replaced by a Scubapro Pilot demand regulator. This second stage has a unique balanced pilot-assisted valve. The balanced demand valve is opened by air pressure controlled by a pilot valve. This second stage design is a change from the conventional downstream type second stage actuated by direct mechanical linkage connecting the diaphram. The pilot valve is sensitive to the slightest pressure differential on the second stage diaphram and has flow passages 3 times the diameter of a conventional second stage. No "Dial-A-Breath" mechanism is incorporated in this regulator. Theoretically the balanced, pilot-assisted regulator should operate satisfactorily at lower supply pressures than a normal second stage and it was this possibility that initiated these tests.

However, it was realized that while the pilot regulator is balanced, the pilot assist valve itself is designed to require a certain supply pressure to operate. Consequently, the regulators ability to operate at lower supply pressures was a function of the operating range of the pilot mechanism. This could be determined only be testing.

A gas supply umbilical connects to the sideblock assembly on the right side of the mask (the mode used in these tests). The sideblock houses a non-return valve in the umbilical supply port and also incorporates a separate gas supply valve and connector for an emergency

gas supply. The emergency supply normally consists of a standard scuba tank and first stage regulator assembly which is worn on the divers back.

In addition, the sideblock houses a defogging valve which may be used to supplement normal demand/free flow operation or to keep the face plate clear by directing a continuous flow of gas across the lens.

The mask frame is constructed of cycolac plastic. It is sealed in place on the divers head with a rubber foam face seal and adjustable five point head harness.

B. Breathing Resistance Tests. Breathing resistance was measured at 75 RMV to simulate heavy diver work. This value was determined by a preliminary test which evaluated mask performance at various breathing rates and tidal volumes. This determined which combination most closely simulated results achieved in reference 3. A synopsis of the results of reference 3 is included in Appendix D for comparison.

Breathing resistance was measured at overbottom supply pressures varying from 135 to 60 psig O/B. These pressures were maintained at the upstream end of 400 feet of 3/8" I.D. standard Navy lightweight diving hose.

Breathing resistances plotted for both mask configurations are the maximum values measured, excluding cracking pressure, during one complete inhalation/exhalation cycle at a given depth and supply pressure. On plots where the data is incomplete, the test was terminated due to excessive breathing resistance.

NOTE: The dotted line representing the Mil Spec limit on Figures 4 through 14 gives the maximum allowed breathing resistance at 40 RMV (20 BPM/2.0 Liter Tidal Volume) only. The 75 RMV tested represents a much higher diver work rate. The Mil Spec limit for 40 RMV is included for comparative purposes only.

In addition, at the maximum test depth of 190 FSW the RMV was reduced to 62.5 (25 BPM/2.5 Liter Tidal Volume) when breathing resistances became excessive at 75 RMV. This technique produced inhalation resistances which were comparable to those recorded in the manned study summarized in Appendix D.

(1) Inhalation Characteristics of the MK 1 Mod 0 Mask in Standard Configuration. It was observed that breathing resistance was very sensitive to "Dial-A-Breath" position. Consequently, the valve was set as previously described at each depth and overbottom pressure to insure uniform test conditions at all data points.

The cracking pressure of the MK 1 Mod 0 mask was quite high in some instances and at times exceeded maximum inhalation resistance measured at peak flow. However, since this initial pressure spike represents very little breathing work it is ignored. The reason for high pressure differentials to initiate flow in a demand regulator is usually an incorrectly adjusted diaphram/linkage assembly. This represents no threat to the divers life support system or its overall performance. This phenomena is illustrated in the typical pressure-volume loop represented in Figures 2 and 3.

At 135 psig O/B supply pressure (Figure 4), inhalation resistance remained approximately constant down to 130 FSW, never exceeding 15 cmH_2O. At 190 FSW resistance increased to over 100 cmH_2O. For comparative purposes the RMV was reduced to 62.5 LPM (25 BPM and 2.5 Liter tidal volume) and breathing resistance was reduced to 32 cmH_2O. This compared closely to manned test results and is a good indication that divers will adapt their RMV at a given work rate to give the lowest breathing resistance even if it means inadequate ventilation for CO_2 removal from their bodies for short periods of time.

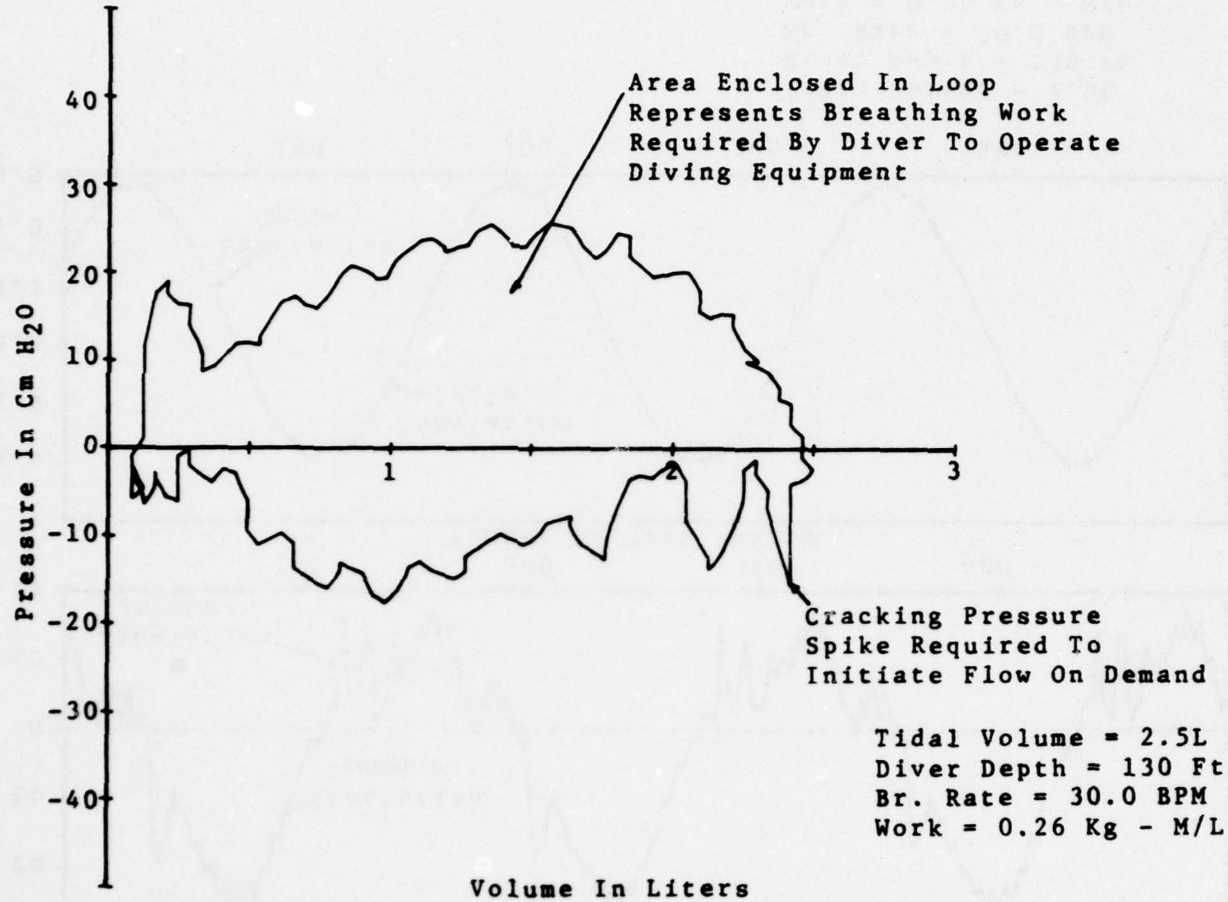
Inhalation resistance at 115 psig O/B (Figure 5) increased drastically (reaching over 40 cmH_2O) at only 130 FSW.

Resistance at 95 and 75 psig O/B (Figures 6 and 7) showed marked increases in inhalation effort at 99 and 60 FSW respectively.

As can be seen from Figures 4-7, inhalation resistance increased rapidly at progressively shallower depths when supply pressure was reduced below the baseline pressure of 135 psig O/B. Refer these figures to Appendix D for a comparison of manned and unmanned results.

(2) Inhalation Characteristics of the MK 1 Mod 0 Mask Modified with Scubapro Pilot Second Stage. The cracking pressure of the MK 1 Mod 0/Pilot was significantly lower than the standard configuration (Figures 8 and 9). This was expected because of the nature of the regulator. However, the extremely high flow capability of the pilot did cause the regulator to be somewhat unstable at depths less than 60 FSW. This instability was seen in the form of large pressure fluctions during the inhalation cycle. This phenomena was eliminated by tuning the regulator for this specific application.

Inhalation resistance at 135 psig O/B (Figure 10) remained constant at 15 cmH_2O down to 130 FSW. At 190 FSW resistance increased to over 70 cmH_2O until the RMV was reduced to 62.5 LPM. Under these conditions effort was reduced to slightly over 20 cmH_2O. This value compared favorably with manned test results (see Appendix D).



Pressure - Volume Loop

FIGURE 2. MK1 MOD O CONSTANT RMV TEST

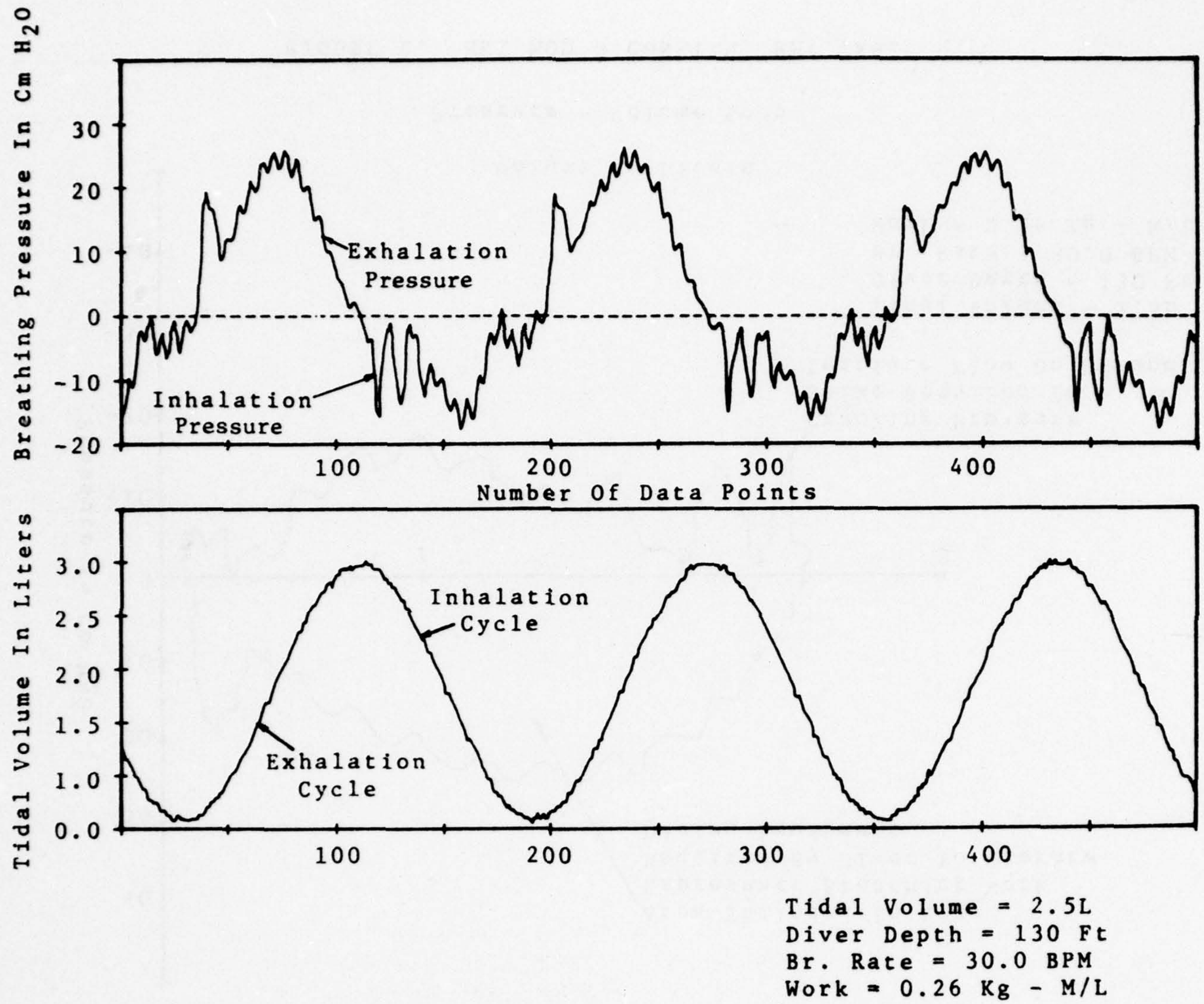
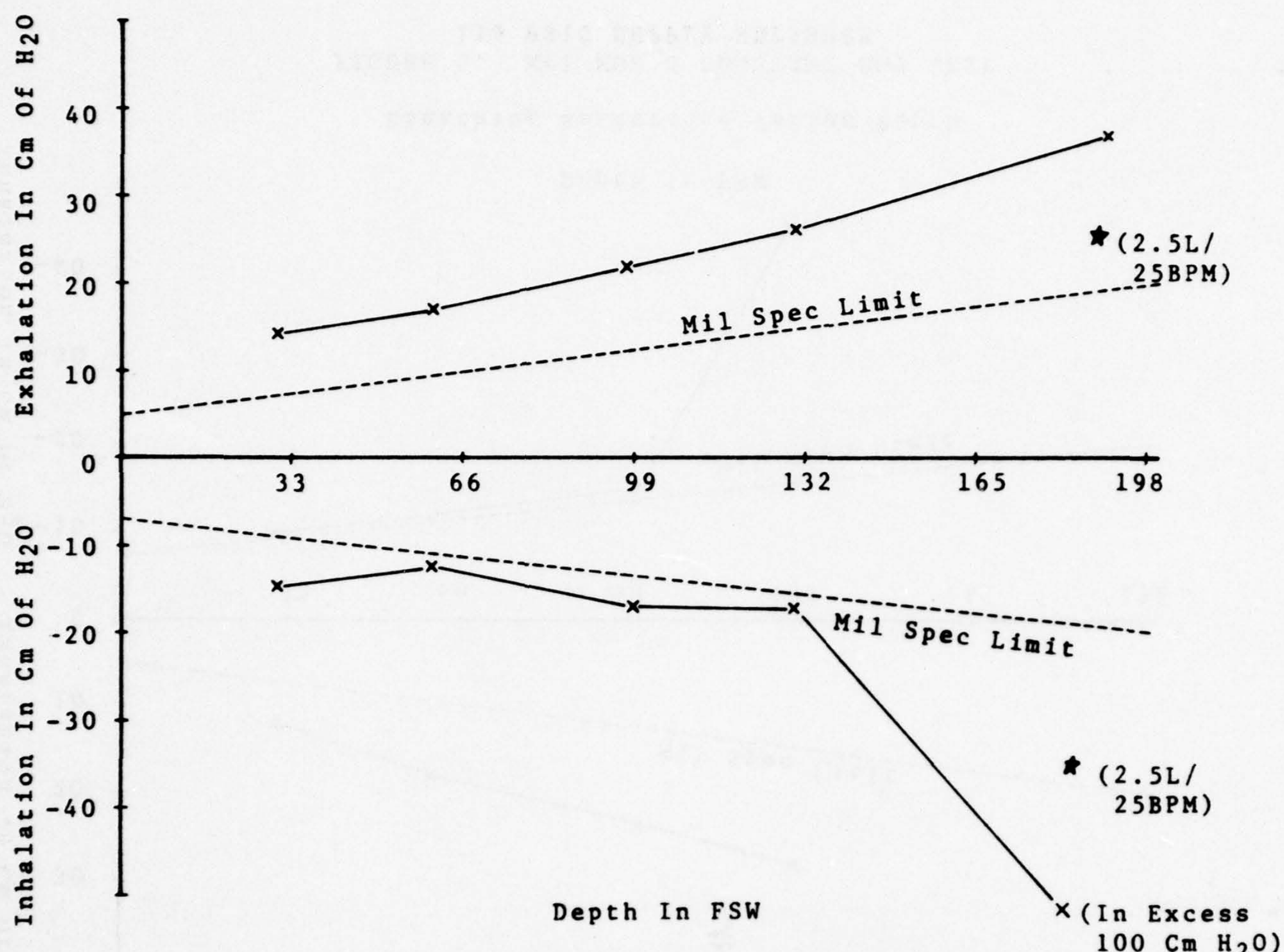
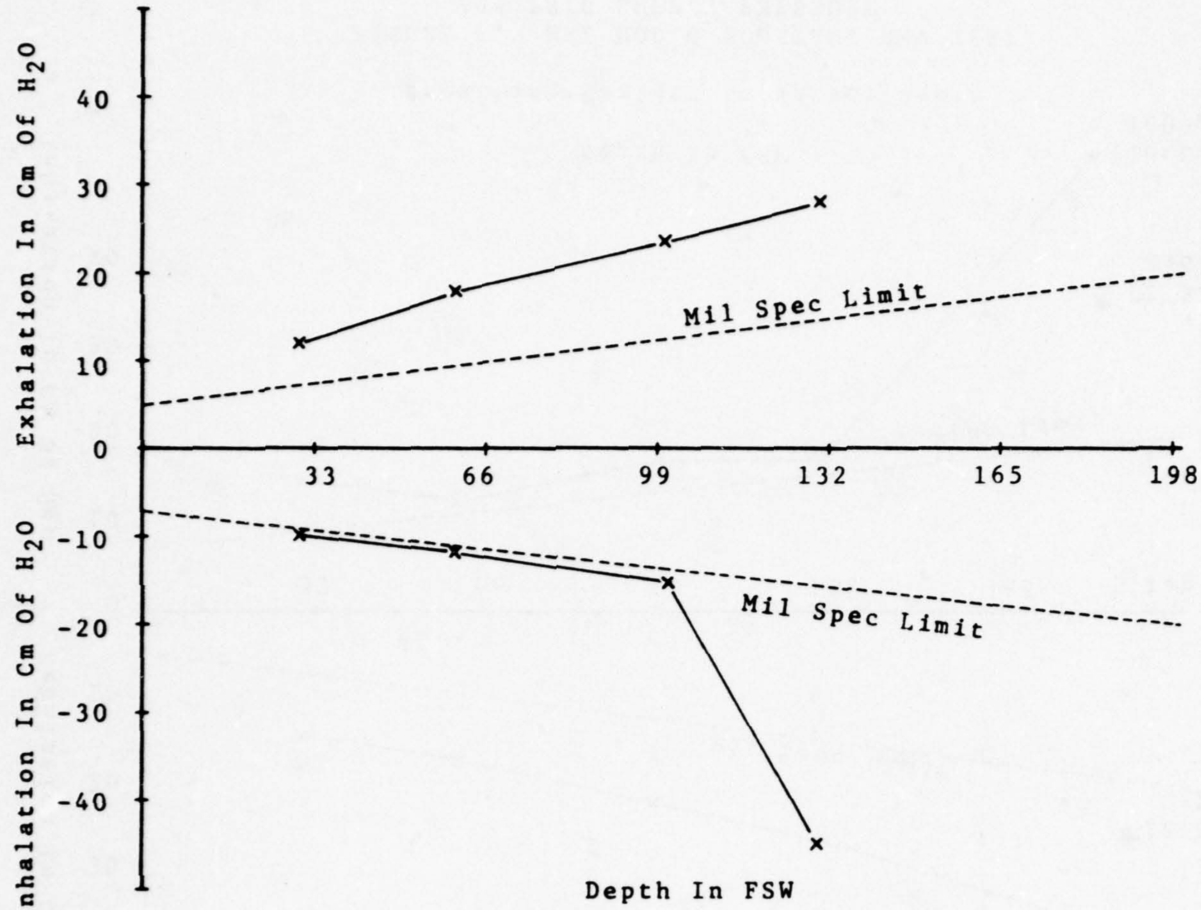


FIGURE 3. MK1 MOD 0 CONSTANT RMV TEST



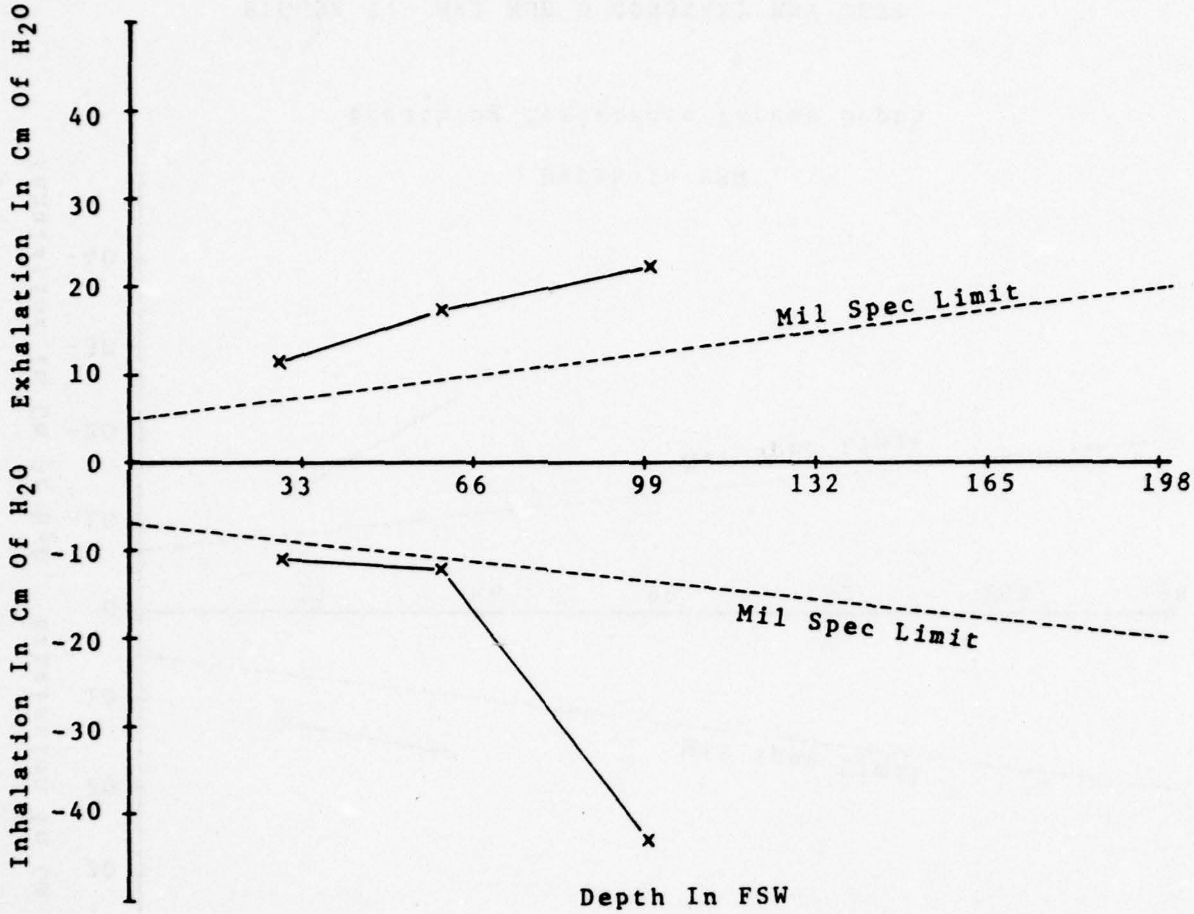
Breathing Resistance Versus Depth

FIGURE 4. MK1 MOD O CONSTANT RMV TEST
135 PSIG SUPPLY PRESSURE



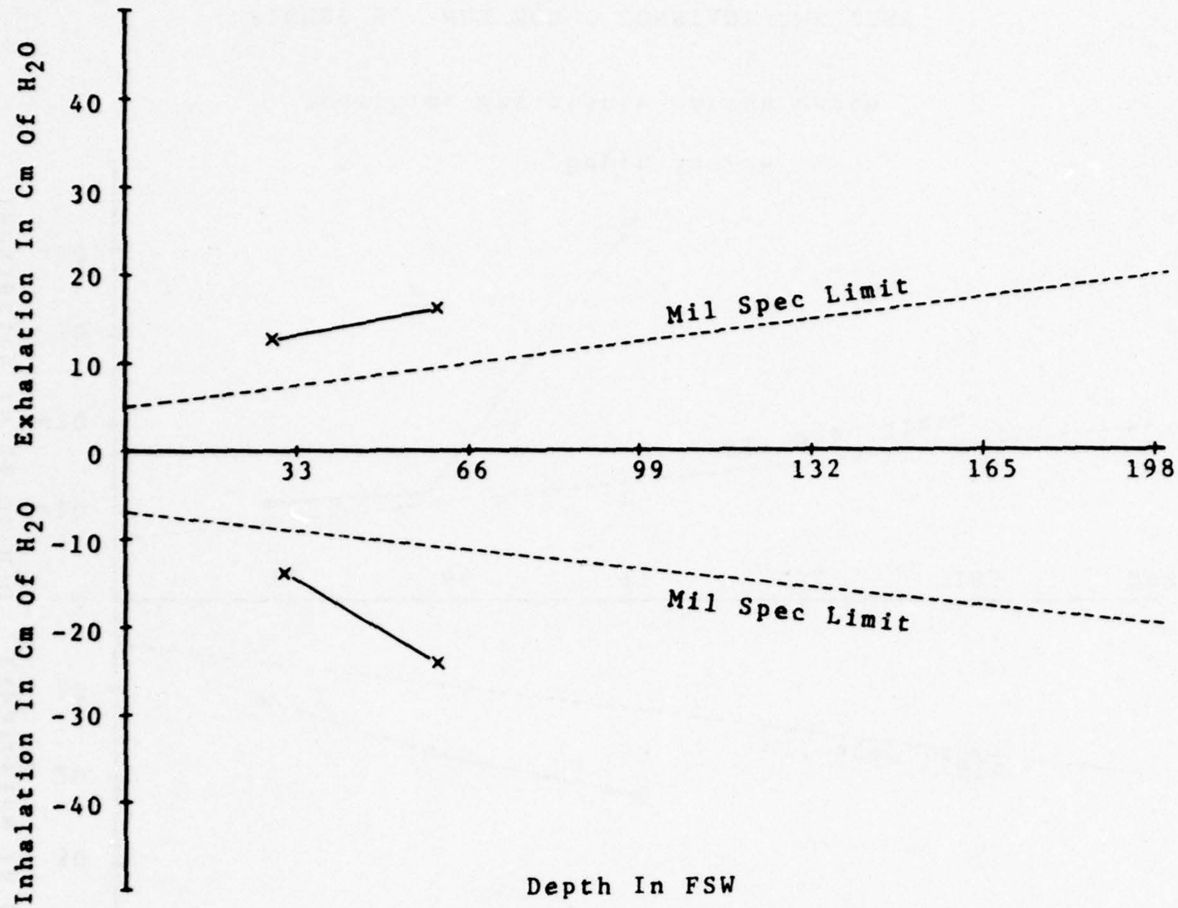
Breathing Resistance Versus Depth

FIGURE 5. MK1 MOD 0 CONSTANT RMV TEST
115 PSIG SUPPLY PRESSURE



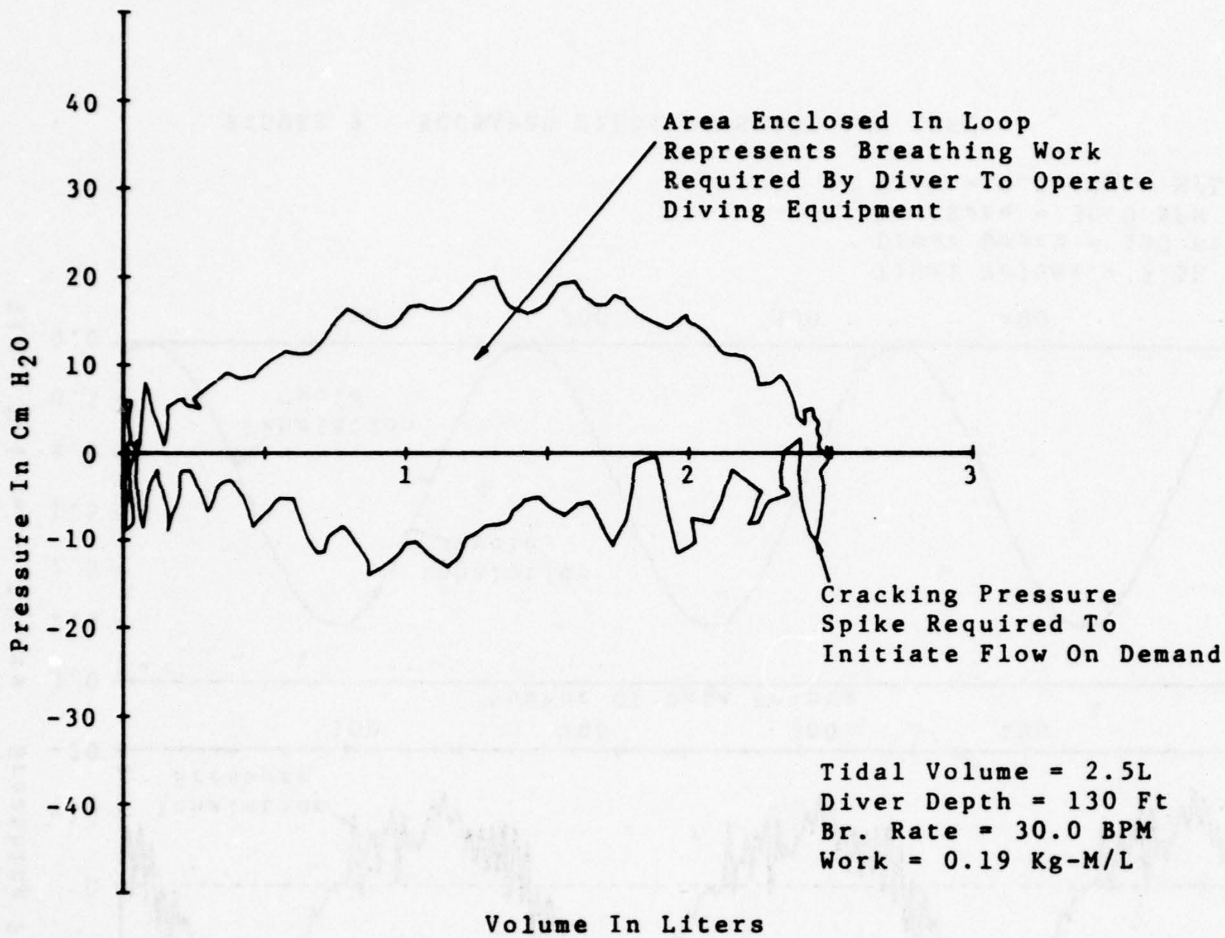
Breathing Resistance Versus Depth

FIGURE 6. MK1 MOD 0 CONSTANT RMV TEST
95 PSIG SUPPLY PRESSURE



Breathing Resistance Versus Depth

FIGURE 7. MK1 MOD O CONSTANT RMV TEST
75 PSIG SUPPLY PRESSURE



Pressure - Volume Loop

FIGURE 8. SCUBAPRO PILOT CONSTANT RMV TEST

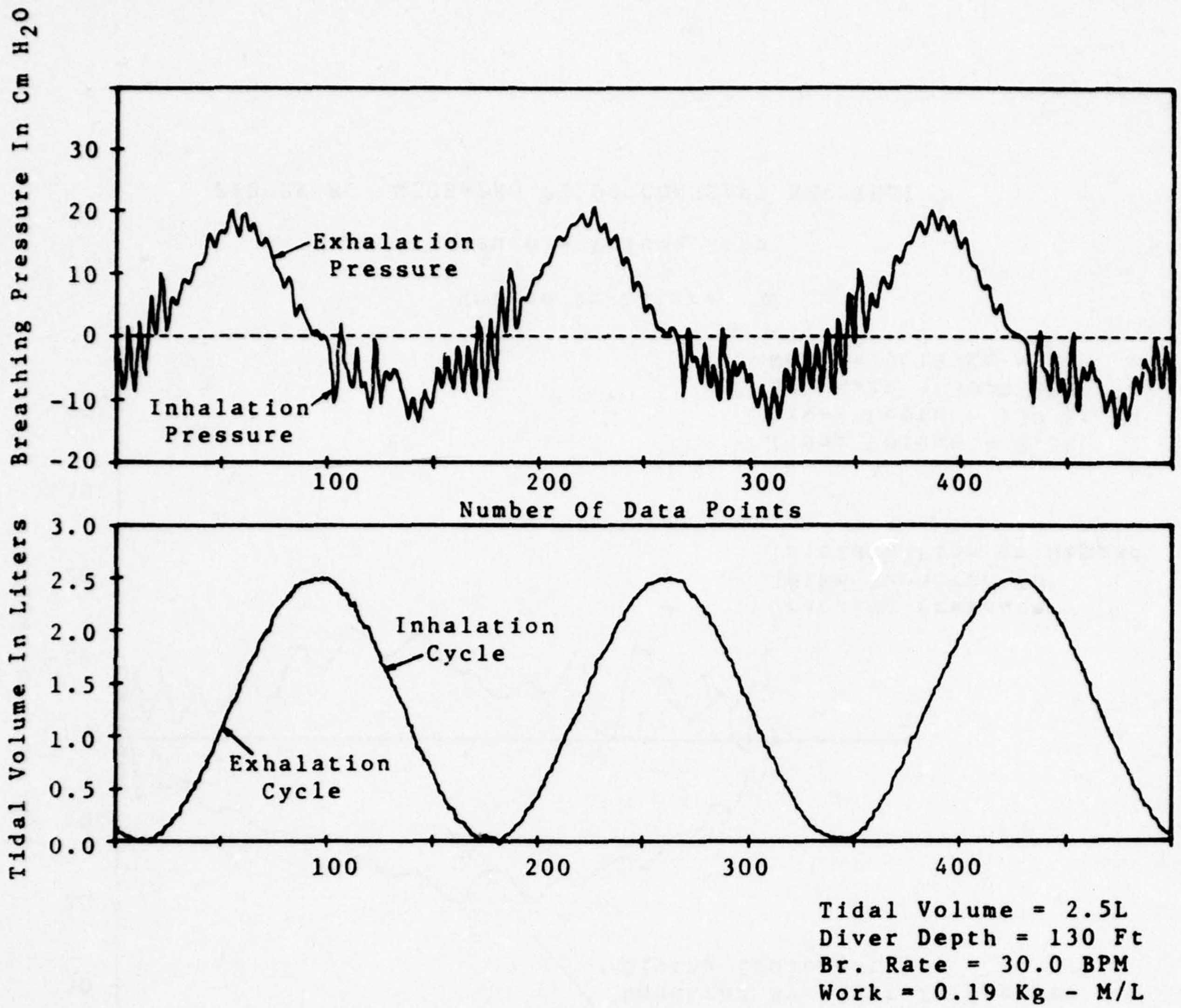
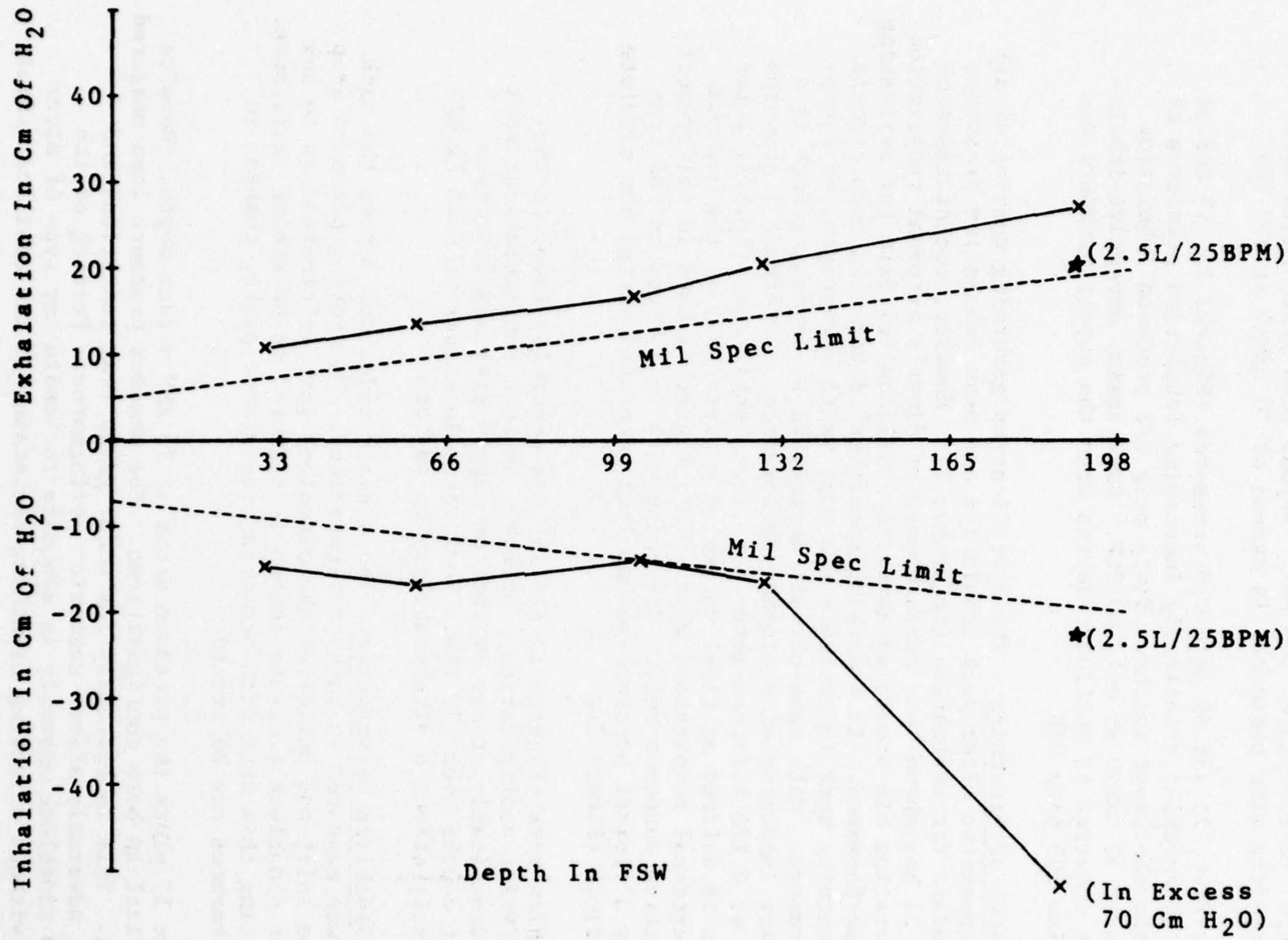


FIGURE 9. SCUBAPRO PILOT CONSTANT RMV TEST



Breathing Resistance Versus Depth

FIGURE 10. SCUBAPRO PILOT CONSTANT RMV TEST
135 PSIG SUPPLY PRESSURE

A supply pressure of 115 psig O/B (Figure 11) produced easy breathing (15 cmH_2O) to a depth of 100 FSW. Beyond this depth resistance increased rapidly with pressures in excess of 70 cmH_2O at 190 FSW.

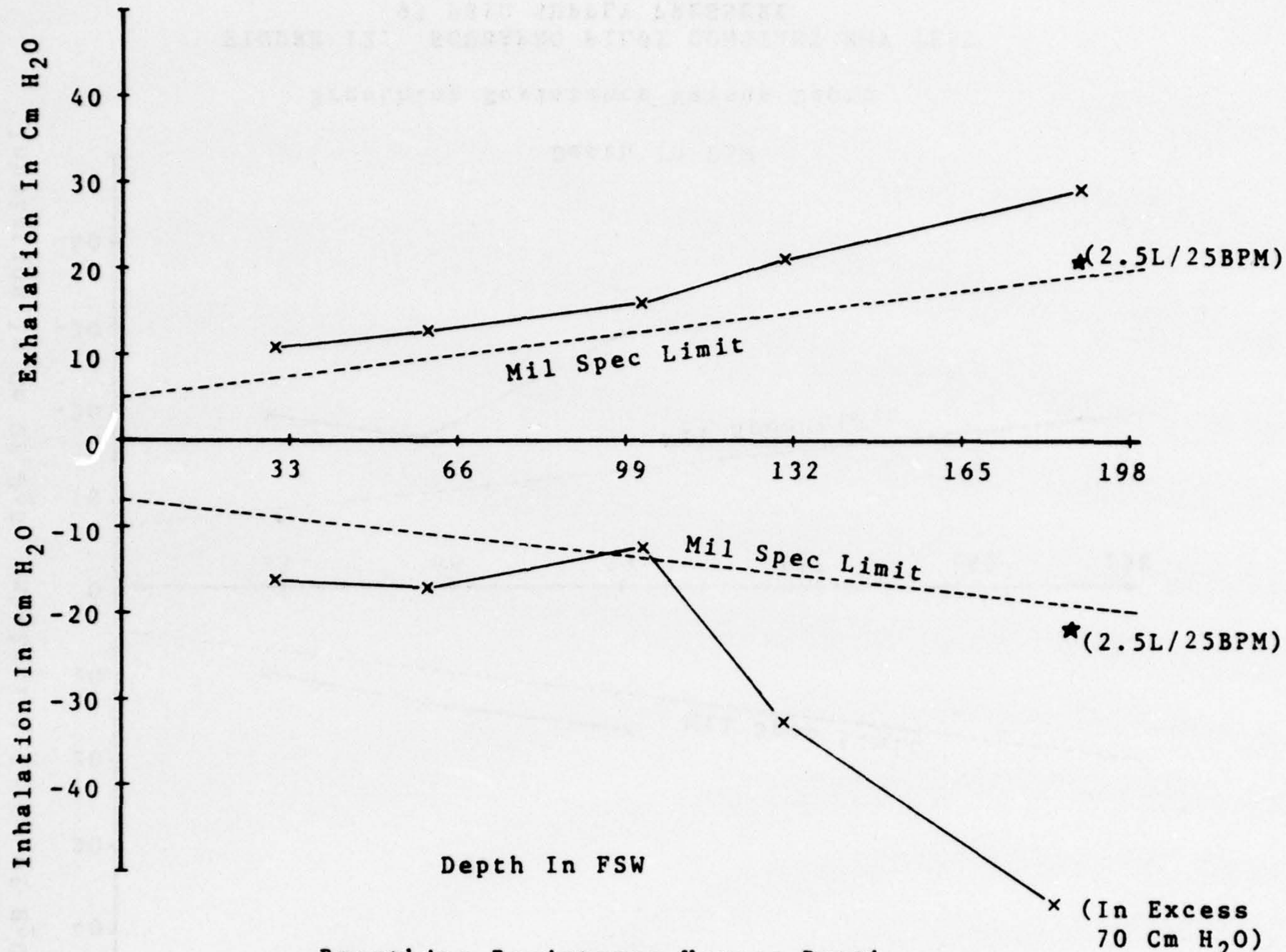
Ninety-five, 75 and 60 psig O/B pressures (Figures 12, 13 and 14 respectively) revealed drastically increasing inhalation pressures at progressively shallower depths. Sixty psig O/B produced inhalation effort of over 50 cmH_2O at only 60 FSW. Once again, excessive inhalation effort occurred at shallower depths when the supply pressure was reduced below 135 psig O/B.

C. Work of Breathing. The specification governing testing of all breathing apparatus cites peak inhalation and peak exhalation pressures as the standard for evaluation (reference 1). However, recent research (reference 2) has shown that measurements of diver's external respiration work in operating his breathing apparatus yield useful data for evaluating equipment performance. In breathing apparatus' other than open circuit demand, breathing work is probably the most valid measurement of equipment performance. With open-circuit demand UBA's, breathing work is a supplementary indicator of equipment performance. Reference 2 proposes a standard of 0.170 kilogram-meter per liter ventilation (kg.m/l; liter ventilation is defined as tidal volume at a given RMV) as the maximum allowable external respiratory work. This figure is used in this report for comparative purposes only. Breathing work is defined as the area enclosed by a typical pressure-volume loop generated during one complete breathing cycle (Figure 2).

Breathing work (Figures 15 and 16) was generally lower in the MK 1 Mod 0/Pilot configuration. However, in both configurations work increased drastically at any overbottom supply pressure less than 135 psig at depths over 130 FSW. Work rates in excess of 0.25 Kg.m/l will adversely affect a divers ability to perform.

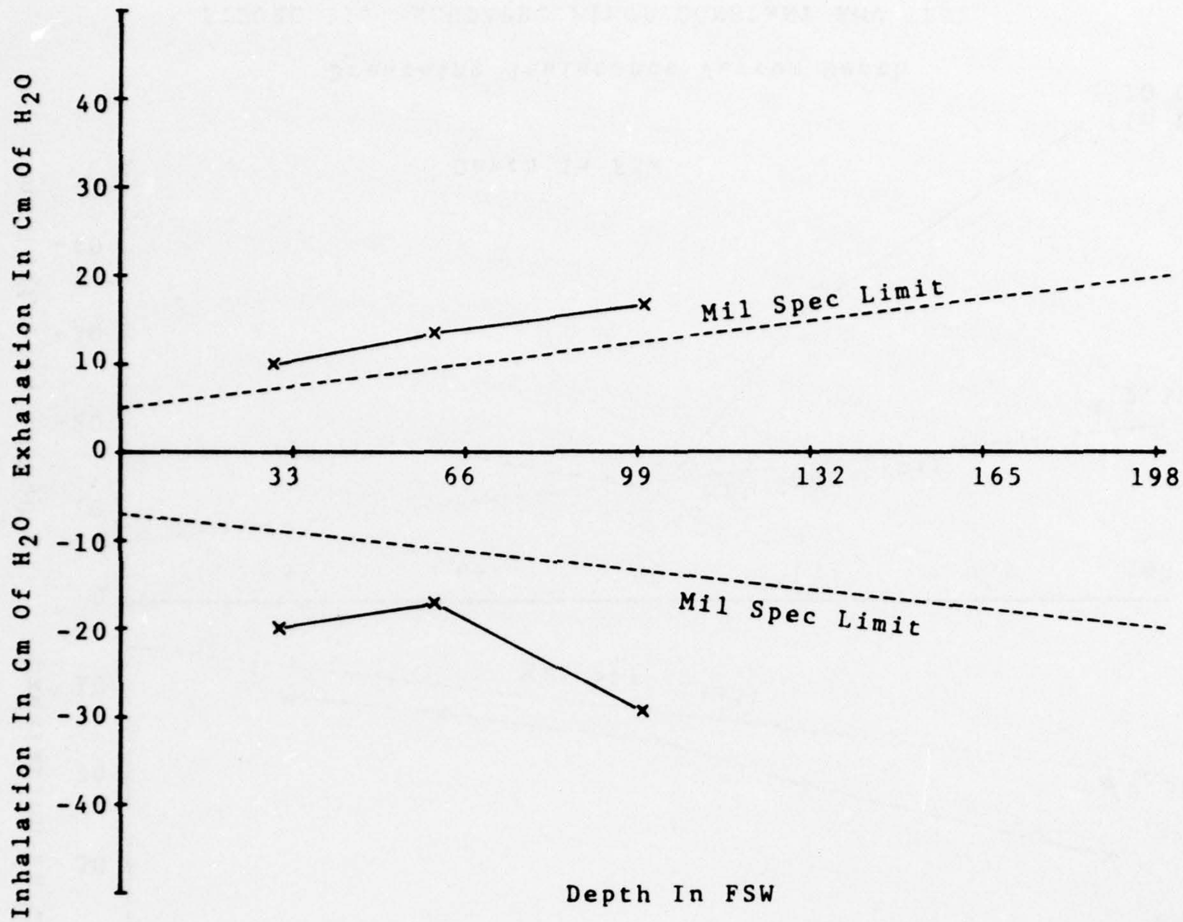
D. Sideblock Performance. The dynamic sideblock across the mask sideblock was measured in both configurations. Monitoring pressure drop between the inlet and outlet of the sideblock gave information as to how much affect sideblock pressure losses contributed to breathing resistance. By correlating this data with breathing resistance plots, changes in mask performances can be traced.

Figure 17 plots the pressure drops at 75 RMV versus depth. Results were identical in both configurations. The maximum pressure loss measured was 8 psig. This is extremely low under given test conditions and should not adversely affect regulator performance. Porting of the MK 1 Mod 0 sideblock assembly is adequate to handle any type of diver work rate without affecting breathing resistance in the umbilical supply mode.



Breathing Resistance Versus Depth

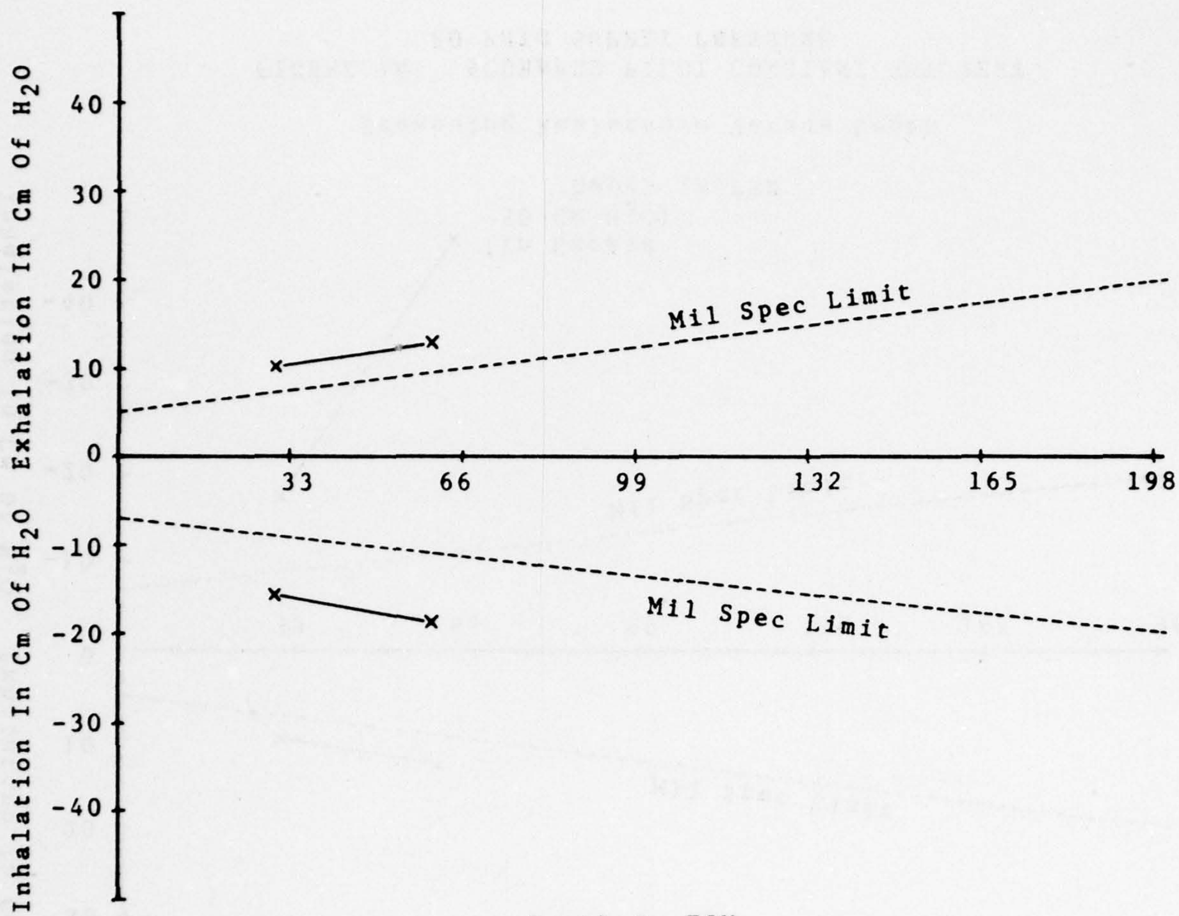
FIGURE 11. SCUBAPRO PILOT CONSTANT RMV TEST
115 PSIG SUPPLY PRESSURE



Depth In FSW

Breathing Resistance Versus Depth

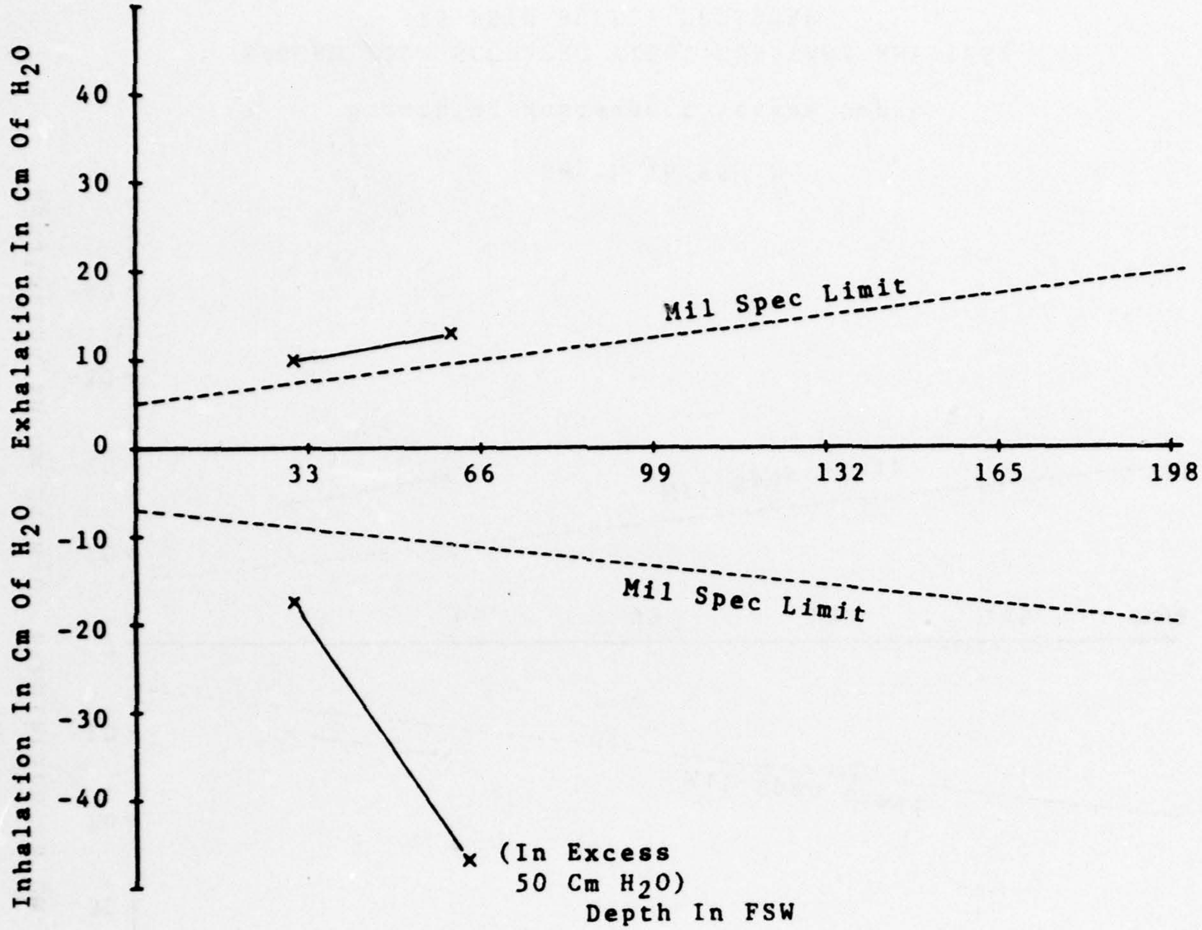
FIGURE 12. SCUBAPRO PILOT CONSTANT RMV TEST
95 PSIG SUPPLY PRESSURE



Depth In FSW

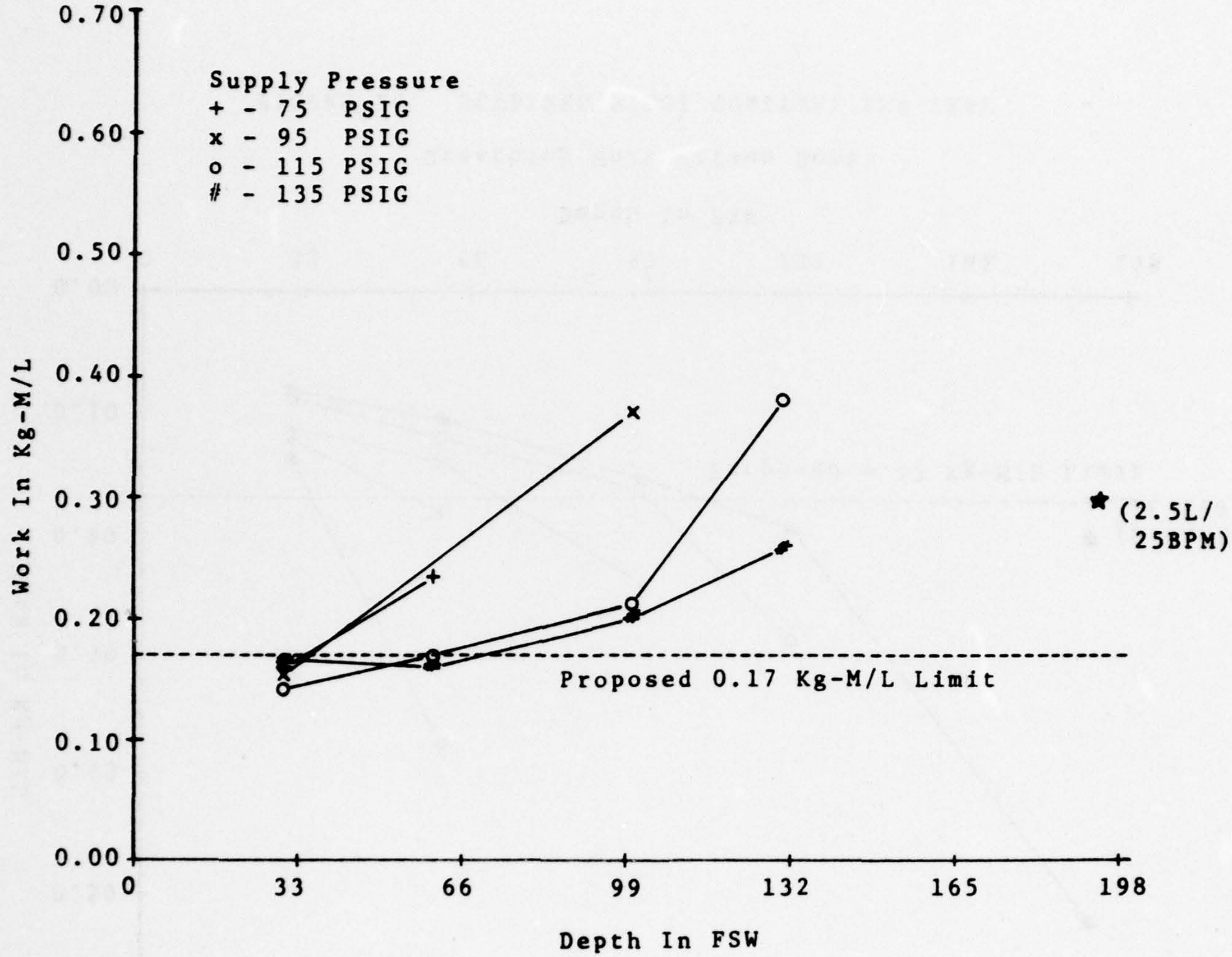
Breathing Resistance Versus Depth

FIGURE 13. SCUBAPRO PILOT CONSTANT RMV TEST
75 PSIG SUPPLY PRESSURE



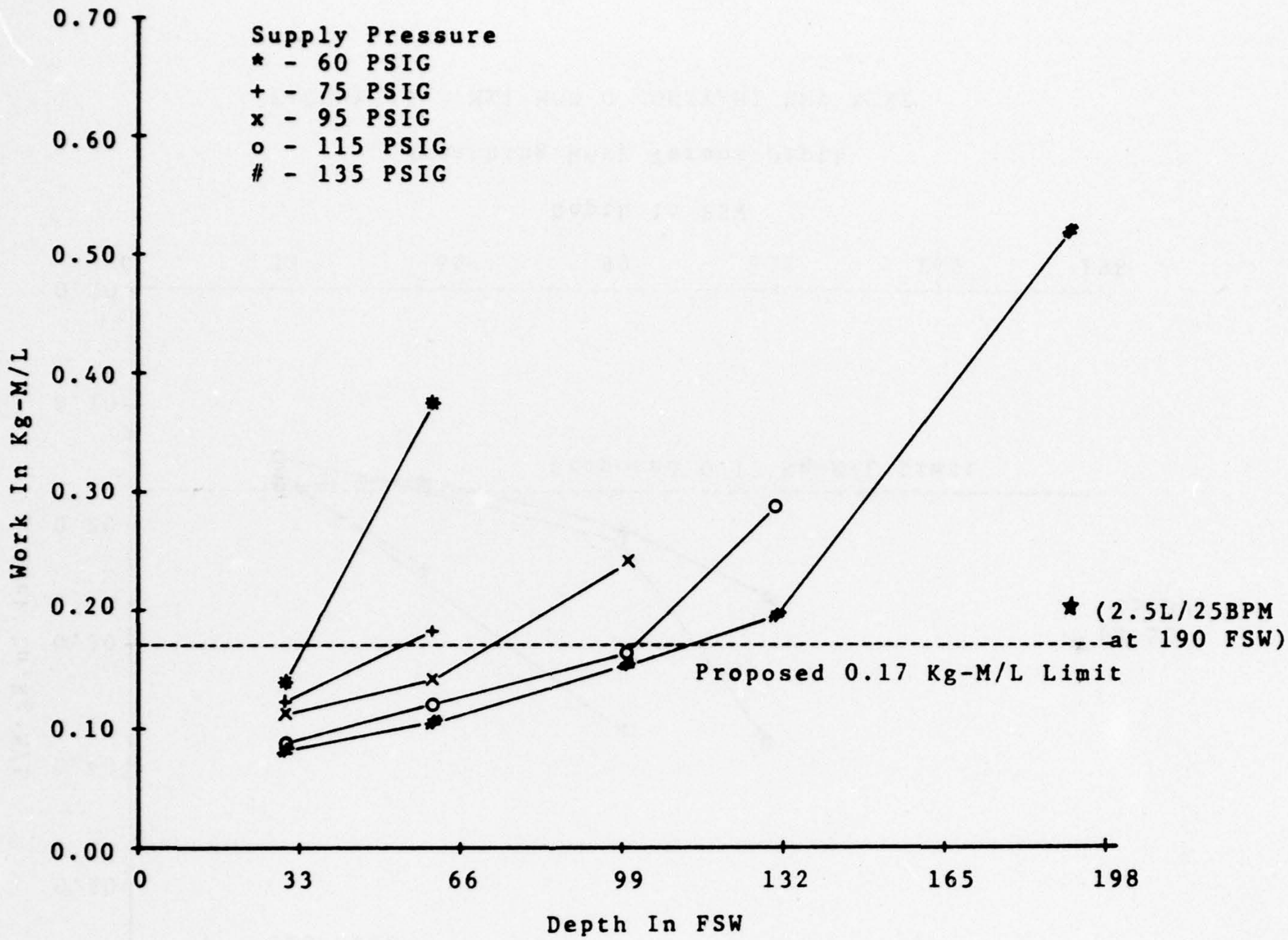
Breathing Resistance Versus Depth

FIGURE 14. SCUBAPRO PILOT CONSTANT RMV TEST
60 PSIG SUPPLY PRESSURE



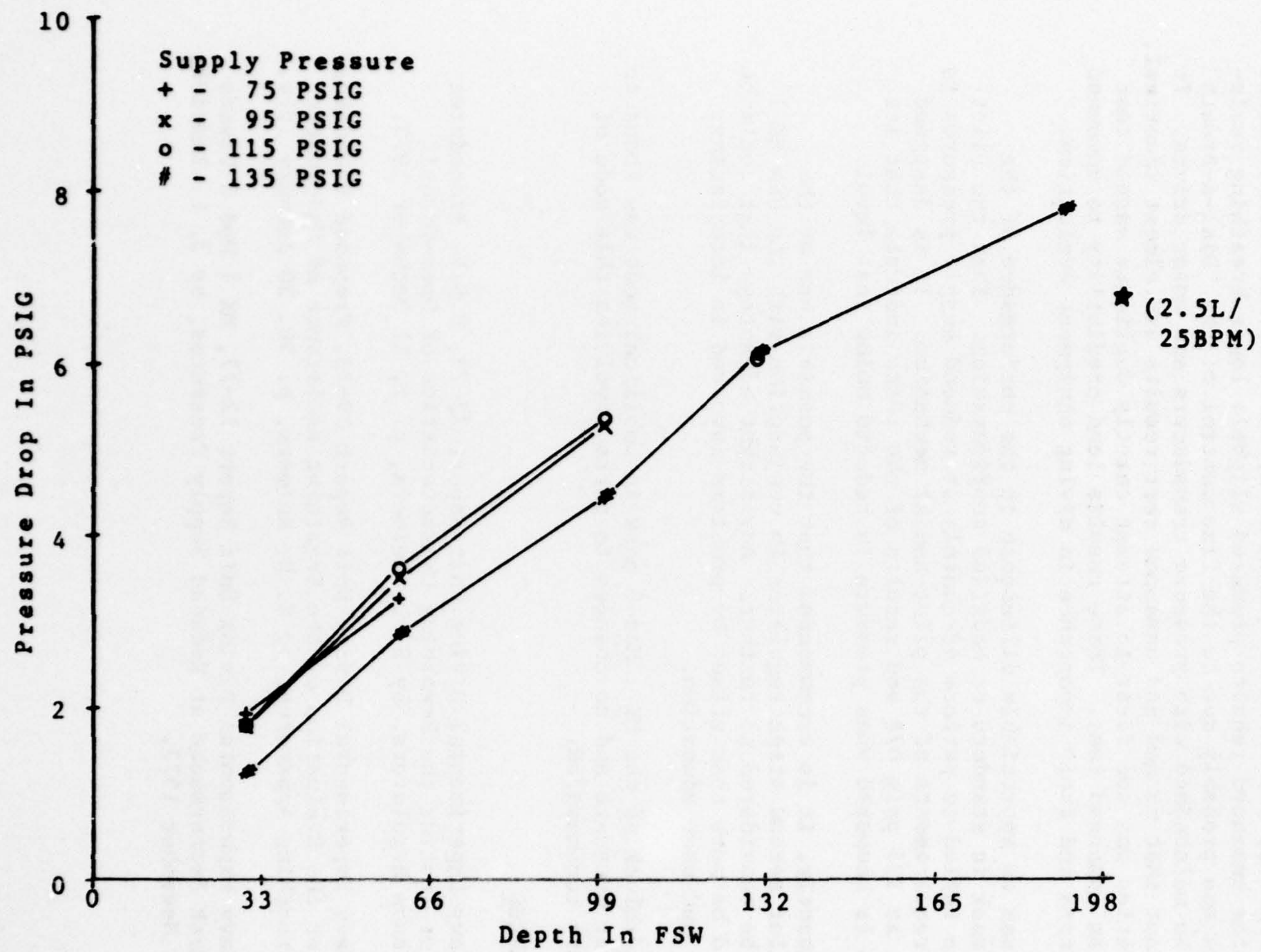
Breathing Work Versus Depth

FIGURE 15. MK1 MOD 0 CONSTANT RMV TEST



Breathing Work Versus Depth

FIGURE 16. SCUBAPRO PILOT CONSTANT RMV TEST



Sideblock Pressure Drop Versus Depth
(Standard And Modified Configuration)

FIGURE 17. MK1 MOD O CONSTANT RMV TEST

IV. CONCLUSIONS AND RECOMMENDATIONS

Breathing resistances of the standard MK 1 Mod 0 were found to compare very closely to results obtained in reference 3 (i.e. 135 psig O/B is the minimum supply pressure required to operate the MK 1 Mod 0 mask). Generally, the unmanned results produced slightly lower breathing resistances which was probably due to the fine control of the "Dial-A-Breath" that could be maintained with pressure transducers and motor drives. It is significant that manned and unmanned test results are almost identical. This test series was the first to attempt exactly duplicate manned test results in an unmanned test. These results lend credibility to unmanned test simulators and their importance in diving equipment evaluation.

There was no appreciable difference in the performance of the MK 1 Mod 0 mask in standard or modified configuration. That the Pilot second stage failed to perform adequately at reduced supply pressures is due to the requirements of the pilot-assist mechanism. It is designed to function at 135 psig O/B and results of the tests indicate that its performance is hampered when pressure is reduced below that level.

Consequently, it is recommended that the possible use of the Scubapro pilot second stage regulator in conjunction with the USN MK 1 Mod 0 mask be considered no further. Any slight advantage that could be gained would be more than offset by problems involved in interfacing, spare parts and user education.

The sideblock of the MK 1 Mod 0 mask in umbilical mode was found to be completely adequate and no changes to parts involving this mode of operation are recommended.

V. REFERENCES

1. Navy Experimental Diving Unit Report 23-73, U.S.N. Procedures for Testing the Breathing Characteristics of Open-Circuit Scuba Regulators, by S. D. Reimers, p. 5, 11 December 1973.

2. Navy Experimental Diving Unit Report 19-73, Proposed Standards for the Evaluation of the Breathing Resistance of Underwater Breathing Apparatus, by S. D. Reimers, p. 36, 30 January 1974.

3. Navy Experimental Diving Unit Report 12-77, MK 1 Mod 0 Divers Mask Performance at Reduced Supply Pressures, by J. L. Zumrick, 6 November 1977.

APPENDIX A

TEST PLAN

MK 1, MOD 0 Mask in Standard Configuration and with Scubapro Pilot Regulator

1. Install in chamber MK 1, MOD 0 Mask with Scubapro pilot and connect instrumentation as shown in Figure 1 except for "Dial-A-Breath" motor drive.

2. Calibrate all sensors.

3. Fill test box with water until water level is 6 inches above the regulator.

4. Install wave suppressor in test box.

5. Set breathing machine at 30 BPM and 2.5 LTV.

6. Close chamber.

7. Set umbilical supply pressure at 135 psig over bottom pressure.

8. Open compliance chamber solenoid valve.

9. Compress chamber to 30 feet H_2O.

10. Close compliance chamber solenoid valve.

11. Set umbilical supply pressure at 135 psig over bottom pressure.

12. Record static reading on all transducers.

13. Record regulator offset pressure.

14. Turn on breathing machine.

15. Record, plot, print, and store data.

16. Change umbilical supply pressure to 115 psig over bottom pressure.

17. Repeat step 14.

18. Change umbilical supply pressure to 90 psig over bottom pressure.

19. Repeat step 14.

20. Change umbilical supply pressure to 75 psig over bottom pressure.

21. Repeat step 14.

22. Change umbilical supply pressure to 60 psig over bottom pressure.

23. Repeat step 14.

24. Change umbilical supply pressure to 135 psig over bottom pressure.

25. Turn off breathing machine.

26. Open compliance chamber solenoid valve.

27. Compress chamber to 60 feet H_2O.

28. Close compliance chamber solenoid valve.

29. Repeat steps 10 through 25.

30. Compress chamber to 100 feet H_2O.

31. Close compliance chamber solenoid valve.

32. Repeat steps 10 through 25.

33. Compress chamber to 130 feet H_2O.

34. Close compliance chamber solenoid valve.

35. Repeat steps 10 through 25.

36. Compress chamber to 190 feet H_2O.

37. Close compliance chamber solenoid valve.

38. Repeat steps 10 through 25.

39. Close umbilical supply valve.

40. Decompress chamber.

41. Bleed supply regulator or dome and umbilical supply hose.

APPENDIX B

TEST EQUIPMENT

1. MK 1 Mod 0 Bandmask Regulator and sideblock
2. Validyne pressure transducer w/25.0 psid diaphram (2 ea)
3. Validyne pressure transducer w/1.00 psid diaphram
4. Validyne CD-19 transducer readout (3 ea)
5. X-Y plotter
6. Hewlette Packard 9825 Data Acquisition System
7. NCSC Hydrospace chamber complex
8. Air pressure gauge (0-3000 psig)
9. Scubapro Pilot Second Stage Regulator
10. Dome loader
11. Breathing machine w/piston position transducer
12. Wet test box
13. Motor Drive to adjust "Dial-a-Breath" knob
14. Bubble Dampening Mat
15. Chamber Depth Gauge
16. 400' 3/8" I.D. umbilical

APPENDIX C

MAN-HOURS REQUIRED

The man-hours required for the test of the USN MK 1 Mod 0 mask are computed below.

	Men	Hours	Man-Hours
Test set-up	3	4	12
Test operation	3	16	48
Chamber operation	1	16	16
Post-test cleanup	2	1	2
Data reduction/report production	1	80	80
Duplicating	4	25	100
TOTAL			258

Subject No.	Work Watts	Depth (FSW)	Differential Pressures (cm H_2O)									
			Overbottom Supply Pressure (PSIG)									
			135	115	95	90	85	80	75	70	65	60
#1	100	190	26	26	36	38	40		54			
	125	130	32	32	36	44	49		60			
	125	100	28	28	34	36	48		60			
	125	60	19	23	24			28	35	42		
	125	30	8	9	9	11	13					
#2	100	190	30	30	40							
	100	130	18	18	38	38	54					
	100	100	23	24	23	32	41	72				
	100	60	16	22	25				44			
	100	30	9	9	8	8	12	16				
#3	125	190	28	30	29	38	44					
	125	130	23	23	28	29	33		42			54
	125	100	20	20	18	20	22	23	26	36		
	125	60	14	17	19	20	22	23	26		36	
	125	30	5	5	6				6		6	9
#4	125	190	36	36	42	50	60					
	125	130	19	18	26	30				35		37
	125	100	26	27	31	36	38		43			
	125	60	19	19	19				23			30
	125	30	12	14	18	22						
#5	125	190	28	28	32	36	54					
	150	130	22	22	25	28	29	32	40	58		
	150	100	22	24	30	30						
	125	60	19	20	26				48			
	125	30	12	15	20	22						
#6	125	190	31	31	34	54						
	125	130	25	25	30	39	45					
	125	100	20	20	29							
	125	60	17	20	30				52			
	125	30	10	10	16	24						

Appendix D

DIFFERENTIAL PRESSURES DEVELOPED AT THE DEPTHS TESTED FOR VARIOUS AIR SUPPLY PRESSURES